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An economic and greenhouse gas emissions evaluation of pasture-based dairy calf-to-beef production systems

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A R T I C L E I N F O

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A B S T R A C T

The objectives of the current study were to investigate the effects of production system on Holstein-Frisian bulls and steers and also to evaluate the profitability and greenhouse gas (GHG) emissions of these production systems. Calves were assigned to one of five production systems; bulls finished indoors on a concentrate *ad libitum* diet for 200 days and slaughtered at 15 months of age (15MO); bulls finished indoors on a concentrate *ad libitum* diet for 100 days and slaughtered at 19 months of age (19AL); bulls supplemented with 5 kg of concentrate dry matter (DM) per head daily at pasture for 100 days and slaughtered at 19 months of age (19PC); steers supplemented with 5 kg DM of concentrate per head daily at pasture for 68 days and slaughtered at 21 months of age (21MO) and steers finished indoors on grass silage plus 5 kg DM of concentrate per head daily for 92 days and slaughtered at 24 months of age (24MO). All calves were rotationally grazed at pasture, supplemented with 1 kg DM of concentrates per head daily, during the first season. With the exception of 15MO all production systems were fed grass silage and 1.5 kg DM of concentrate during the winter period and returned to pasture for a second season. The Grange Dairy Beef Systems Model was used to simulate whole-farm system effects of production systems while GHG emissions associated with production were simulated using the Beef Systems Greenhouse Gas Emissions Model. Carcass weight was lowest for 21MO, greatest for 19AL and 24MO with both 15MO and 19PC intermediate. Conformation score was greater for bull (15MO, 19AL and 19PC) compared to steer production systems (21MO and 24MO). Fat score was greatest for 24MO and lowest for both 15MO and 19PC; 19AL and 21MO were intermediate. Concentrate feed costs represented 68, 59, 47, 39 and 39% of the total variable costs for 15MO, 19AL, 19PC, 21MO and 24MO, respectively. The most profitable production system was 19PC, while the least profitable systems were 15MO and 24MO. Greenhouse gas emissions, on a per kg live weight and carcass weight basis were lowest for 15MO and 19AL and greatest for 21MO and 24MO. The current study showed that slaughtering bulls at 19 months of age and finishing at pasture was the most profitable production system with moderate GHG emissions.

1. Introduction

The recent abolition of European Union (EU) milk quota and subsequent expansion of the dairy herd has resulted in a greater proportion of beef derived from the dairy sector (European Commission, 2015). Future beef consumption in the EU is predicted to be greater than indigenous production (European Commission, 2015), with dairy beef production systems assuming greater prominence in meeting this beef deficit. Therefore economic and environmentally sustainable production systems specific to dairy origin cattle are of interest.

In Ireland pasture based production systems predominate with compensatory growth an integral part of the system. For beef production systems feed costs are the greatest factor effecting profitability accounting for 74% of total variable costs (TVC; Ashfield, Wallace, Prendiville and Crosson, 2014). While increasing the utilisation of grazed grass in the production system has the potential to reduce the cost of production (Finneran et al., 2012), compared to a concentrate *ad libitum* diet carcass weight, gain and fat score are significantly reduced (French, O'Riordan, O'Kiely, Caffrey, & Moloney, 2001). Additionally the reduced rate of gain can prolong the finishing period resulting in animals in pastoral systems being older at slaughter.

In an effort to reduce the age at slaughter and increase the efficiency of beef production systems, producers have benefitted from the superior biological performance of bulls compared to steers (Nogalski et al., 2014). Bull and steer production systems differ with regard to finishing

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intensity, age at slaughter and the proportion of grazed grass in the diet (Clarke et al., 2009). Typically bulls are finished on concentrate intensive diets over a prolonged period and slaughtered between 16 and 20 months of age (Keane & Fallon, 2001; Kirkland, Patterson, Keady, Moss, & Steen, 2007). Incorporating grazed grass in the diet of bull production systems together with compensatory growth has the potential to reduce the cost of production and increase overall profitability (Ashfield, Wallace, Prendiville et al., 2014). In contrast, steers are predominantly finished at older ages indoors on a grass silage and concentrate diet (Nogalski et al., 2014) or returned to pasture and slaughtered at 26 to 30 months of age (Keane & Allen, 1998). Thus, identifying low cost bull and steer production systems is essential.

Concerns regarding global warming and climate change have led to increased scrutiny of agricultural production systems (Crosson et al., 2011). The publication of the greenhouse gas (GHG) emissions reduction targets by the EU (European Commission, 2016) has intensified this debate. Many studies have compared GHG emissions from alternative suckler beef production systems (Foley et al., 2011; Morel et al., 2016). Studies have also investigated dairy calf-to-beef systems (Cederberg & Stadig, 2003; Bonesmo, Beauchemin, Harstad, & Skjelvåg, 2013), however beef production was considered a co-product of milk production and animals were finished within a single production system and thus, no comparison of alternative finishing strategies was provided. Therefore, a whole farm analysis, comparing a range of dairy calf-to-beef production systems, is necessary to quantify production, economic and GHG emissions performance.

Therefore, the objectives of the current study were, for Holstein-Friesian bull and steer production systems, to: (1) evaluate the effects of production system (age at slaughter and finishing strategy) on animal performance; (2) evaluate production costs and the profitability of these systems, and; (3) quantify GHG emissions per unit of area farmed and beef produced.

2. Materials and methods

This study was conducted at the Teagasc Johnstown Castle research farm (52° 17′ N, 6° 30′ W) from 2013 to 2016 on a grassland sward of predominantly perennial ryegrass (*Lolium perenne*). Data were available for 147 spring-born Holstein-Friesian male calves purchased in livestock marts over 2 consecutive years (74 and 73 in 2013 and 2014, respectively). Mean date of birth and age at arrival were 6 February and 37 (s.d. 31.7) days, respectively. Calves were artificially reared on site. Post-weaning (80 kg), calves were turned out to pasture for the first season and housed in November. Calves were blocked by birth date, farm of origin and weaning weight and randomly assigned to one of five production systems 1) bulls finished indoors on a concentrate *ad libitum* diet for 200 days and slaughtered at 15 months of age (15MO); 2) bulls offered grass silage *ad libitum* plus 1.5 kg of concentrate dry matter (DM) per head daily over the winter period, turned out to pasture for 100 days, and finished indoors on a concentrate *ad libitum* diet for 100 days and slaughtered at 19 months of age (19AL); 3) bulls offered grass silage *ad libitum* plus 1.5 kg DM of concentrate per head daily over the winter period, turned out to pasture for 100 days, finished at pasture supplemented with 5 kg DM of concentrate per head daily for 100 days and slaughtered at 19 months of age (19PC); 4) steers offered grass silage *ad libitum* plus 1.5 kg DM of concentrate per head daily over the winter period, turned out to pasture for 175 days, finished at pasture supplemented with 5 kg DM of concentrate per head daily for 60 days and slaughtered at 21 months of age (21MO) and 5) steers offered grass silage *ad libitum* plus 1.5 kg DM of concentrate per head daily over the winter period, turned out to pasture for 210 days, and finished indoors on grass silage *ad libitum* plus 5 kg DM of concentrate per head daily and slaughtered at 24 months of age (24MO). Production systems rather than distinct treatments were evaluated, thus confounding of some variables (age at slaughter, finishing strategy and sex) was inevitable. Calves were generated by artificial insemination from 76 Holstein-Friesian sires, commonly available in Ireland, 16 stock bulls (sired 24 calves) and 19 calves had an unknown sire.

2.1. Animal management

During the first season at pasture calves were offered 1 kg DM of concentrate per head daily and rotationally grazed on a paddock system for 190 days (s.d. 2.9). Calves assigned to the steer production systems were castrated at 6 months of age. In early November calves were housed on slatted floor accommodation.

At housing 15MO ($n = 30$) were penned in groups of 5 to give 6 replicates per treatment and immediately adapted to a concentrate *ad libitum* diet over a 21 day period. Fresh concentrates were offered daily with concentrate weigh-backs completed twice weekly to measure individual concentrate DM intake (CDMI). Straw was offered *ad libitum*. Bulls were finished over a 200 day (s.d. 14.2) period and slaughtered in May or June, depending on date of birth, at 474 days of age (s.d. 8.7).

The remaining treatment groups were offered grass silage *ad libitum* plus 1.5 kg DM of concentrate per head daily for 141 days (s.d. 5.1) over the winter period. The 19AL, 19PC, 21MO and 24MO were returned to pasture for a second season. Due to extremely wet weather conditions in year 2, 21MO and 24MO were turned out to pasture for a period, rehoused and returned to pasture once grazing conditions improved. Both 19AL and 19PC were turned out to pasture and remained at pasture until housing for finishing (19AL) or until slaughter (19PC). After 69 days (s.d. 10.6) at pasture 19AL were housed and acclimatised to an indoor concentrate *ad libitum* diet over a 21 day period. Similar to 15MO, 19AL were group penned with concentrates offered daily and weigh-backs completed twice weekly. Straw was also available on an *ad libitum* basis. Simultaneously 19PC remained at pasture and were adapted to 5 kg DM of concentrates per head daily over a 10 day period. Concentrates were offered in one feed each morning with a fresh allocation of pasture. Both 19AL and 19PC were finished over a 100 day (s.d. 2.5) period and slaughtered at 587 days of age (s.d. 12.7).

Steers in the 21MO group were rotationally grazed for 167 days (s.d. 6.6) during the second season at pasture. In mid-September 21MO were adapted to 5 kg DM of concentrate per head daily over a 10 day period at pasture. Management of 21MO during the finishing period was similar to 19PC where concentrates were offered in a single feed each morning. The 21MO group were finished over a 68 day (s.d. 8.6) period and slaughtered at 642 days of age (s.d. 14.0). The 24MO group remained at pasture for the entire second grazing season (225 days (s.d. 9.7)). In early November 24MO were housed in slatted floor accommodation and adapted to grass silage *ad libitum* plus 5 kg DM of concentrate per head daily over a 10 day period. The 24MO group were finished over a 92 day (s.d. 0) period and slaughtered at 729 days of age (s.d. 9.7).

Pre- and post-grazing sward heights were recorded using a rising plate meter (Jenquip, Fielding, New Zealand). Across all production systems pre- and post-grazing sward heights during the first season at pasture were 11.1 cm (s.d. 1.50) and 5.9 cm (s.d. 1.19), respectively. During the second season at pasture pre- and post-grazing sward heights were 11.5 cm (s.d. 3.32) and 4.4 cm (s.d. 0.85), respectively. Pre- and post- grazing sward heights were 8.3 cm (s.d. 2.39) and 4.4 cm (s.d. 0.84), respectively, for both 19PC and 21MO during the finishing period. Animals were weighed on a fortnightly basis over the experimental period using a 'Weigh Crate' (O'Donovan's Engineering, Cork, Ireland) and the 'Winweigh' software package (Tru-test limited, Auckland, New Zealand). Animals were weighed at housing, turnout and again 4 days later, to decrease the variation caused by gut-fill. Average daily gain (ADG) during the first season at pasture, first winter, second season at pasture and finishing period were calculated using linear regression of live weight against recording date.

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